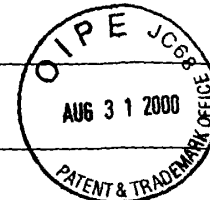
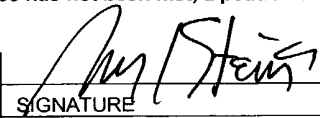


412 Rec'd PCT/PTO 31 AUG 2000

FORM PTO-1390		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 58799-016
<b>TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371</b>			U.S. APPLIC. NO. (if known, see 37 CFR 1.5) <b>09/623273</b>
INTERNATIONAL APPLICATION NO. PCT/JP99/06256	INTERNATIONAL FILING DATE November 10, 1999	PRIORITY DATE CLAIMED	
TITLE OF INVENTION GAS TURBINE UNIT AND ITS COOLING METHOD			
APPLICANT(S) FOR DO/EO/US Kazunori YAMANAKA, Masami NODA, Shinya MARUSHIMA, and Satoshi KONDO			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:			
1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371. 3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1). 4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US) 6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)). 7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendment has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).			
<b>Items 11. to 16. below concern other document(s) or information included:</b>			
11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input checked="" type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 14. <input type="checkbox"/> A substitute specification. 15. <input type="checkbox"/> A change of power of attorney and/or address letter. 16. <input checked="" type="checkbox"/> Other items or information.			
Form PCT/IB/301			



534 Rec'd PCT/PTO 31 AUG 2000

U.S. APPLIC. NO. (if known, see 37 CFR 1.50) <b>09/623273</b>		INTERNATIONAL APPLICATION NO. PCT/JP99/06256		ATTORNEY'S DOCKET NUMBER 58799-016	
				CALCULATIONS	PTO USE ONLY
17. <input checked="" type="checkbox"/> The following fees are submitted:  <b>Basic National Fee (37 CFR 1.492(a)(1)-(5)):</b> Search Report has been prepared by the EPO or JPO <span style="float: right;">\$840.00</span>  International preliminary examination fee paid to USPTO (37 CFR 1.482) <span style="float: right;">\$670.00</span> No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) <span style="float: right;">\$690.00</span>  Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO <span style="float: right;">\$970.00</span>  International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) <span style="float: right;">\$96.00</span>  <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>				\$ 970.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input checked="" type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$ 130.00	
Claims	Number Filed	Number Extra	Rate		
Total Claims	24 -20 =	4	x \$18.00	\$ 72.00	
Independent Claims	21 -3 =	18	x \$78.00	\$ 1,404.00	
Multiple dependent claim(s) (if applicable)			+ \$260.00	\$	
<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$ 2,576.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				\$	
<b>SUBTOTAL =</b>				\$ 2,576.00	
Processing fee of \$130.00 for furnishing the English translation later than the <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
<b>TOTAL NATIONAL FEE =</b>				\$ 2,576.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property				\$	
<b>TOTAL FEES ENCLOSED =</b>				\$ 2,576.00	
				Amount to be: refunded	\$
				charged	\$
a. <input type="checkbox"/> A check in the amount of \$ _____ to cover the above fees is enclosed. b. <input checked="" type="checkbox"/> Please charge my Deposit Account No. <u>500417</u> in the amount of \$ <u>2,576.00</u> to cover the above fees. A duplicate copy of this sheet is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>500417</u> . A duplicate copy of this sheet is enclosed.					
<b>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</b>					
SEND ALL CORRESPONDENCE TO:					
McDERMOTT, WILL & EMERY 600 13 <sup>th</sup> Street, N.W. Washington, DC 20005-3096 (202) 756-8000 Facsimile (202) 756-8087					
 SIGNATURE Arthur J. Steiner NAME 26,106 REGISTRATION NUMBER August 31, 2000 DATE					



Docket No.: 58799-016

09/623,273  
JC10 Rec'd PCT/PTO 31 JAN 2002

PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of :  
Kazunori YAMANAKA, et al. :  
Serial No.: 09/623,273 : Group Art Unit: not yet assigned  
Filed: August 31, 2000 : Examiner: not yet assigned  
For: GAS TURBINE UNIT AND ITS COOLING METHOD

**REQUEST FOR FILING RECEIPT**

Commissioner for Patents  
Washington, DC 20231

Sir:

The above-referenced patent application was filed in the U.S. Patent and trademark Office on August 31, 2000, as evidenced by the attached copies of the return receipt postcard and Transmittal Letter. To date, the undersigned has not received an official filing receipt regarding this application. It is respectfully requested that the undersigned be furnished with an official filing receipt as soon as possible.

Respectfully submitted,

MCDERMOTT, WILL & EMERY

  
Michael E. Fogarty  
Registration No. 36,139

600 13<sup>th</sup> Street, N.W.  
Washington, DC 20005-3096  
(202) 756-8000 MEF:jgh  
**Date: January 31, 2002**  
Facsimile: (202) 756-8087

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

ATTORNEY'S DOCKET NUMBER

58799-016

U.S. APPLIC. NO. (if known, see 37 CFR 1.5)

INTERNATIONAL APPLICATION NO.

PCT/JP99/06256

INTERNATIONAL FILING DATE

November 10, 1999

PRIORITY DATE CLAIMED

TITLE OF INVENTION

GAS TURBINE UNIT AND ITS COOLING METHOD

APPLICANT(S) FOR DO/EO/US

Kazunori YAMANAKA, Masami NODA, Shinya MARUSHIMA, and Satoshi KONDO

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendment has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.  
☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information.

Form PCT/IB/301

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09/623275

534 Rec'd PCT/PTG 31 AUG2000

Docket No.: 58799-016

PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of :  
Kazunori YAMANAKA, et al. :  
Serial No.: : Group Art Unit:  
Filed: August 31, 2000 : Examiner:  
For: GAS TURBINE UNIT AND ITS COOLING METHOD

**PRELIMINARY AMENDMENT**

Assistant Commissioner for Patents  
Washington, DC 20231

Sir:

Prior to examination of the above-referenced application, please amend the application as follows:

**IN THE CLAIMS:**

Please substitute the attached claims as amended under PCT Article 34 for the claims as filed.

Claim 8 of the claims as amended, lines 1 and 2, please change "any one of claims 5 through 7" to --claim 5--.

Claim 13 of the claims as amended, lines 1 and 2, please change "any one of claims 5 through 7" to --claim 5--.


Claim 14 of the claims as amended, lines 1 and 2, please change "any one of claims 5 through 7" to --claim 5--.

REMARKS

The above-referenced application is amended to substitute the claims as amended under PCT Article 34 for the claims as filed and to delete the multiple dependency of claims 8, 13, and 14 to avoid the multiple dependent claim filing fee.

Respectfully submitted,

MCDERMOTT, WILL & EMERY

  
Arthur J. Steiner  
Registration No. 26,106

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**Date: August 31, 2000**  
Facsimile: (202) 756-8087

3/PRTS

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09/62327

- 1 -

534 Rec'd PCT/PTG 31 AUG2000

## SPECIFICATION

### GAS TURBINE UNIT AND ITS COOLING METHOD

#### Technical Field

The present invention relates to a gas turbine unit and a gas-turbine cooling method.

#### Background Art

It is required to increase the capacity and the efficiency of gas-turbine power-generating equipment to meet the ever-increasing demand of electric power and address the problem of the warming up of the earth. In the case of gas-turbine power-generating equipment, in particular, wherein air compressed by a compressor is fed to a combustor, fuel is fed to the combustor to be burned, and the combustion gas drives a gas turbine, its capacity and efficiency can be increased by raising the combustion temperature.

However, the gas turbine exposed to and driven by combustion gas of high temperature may be damaged, if not cooled, and such damage may lead to a serious accident of the gas-turbine power-generating equipment. Therefore, in the gas-turbine power-generating equipment using the

high-temperature combustion gas, the high-temperature part of the gas turbine is cooled with compressed air or steam.

Besides, the efficiency of gas-turbine power-generating equipment can be increased by collecting heat from the refrigerant after it cools the high-temperature part of the gas turbine. On the other hand, it is desirable to reduce the flow rate of the refrigerant as low as permissible.

The configuration of the cooling holes to cool the high-temperature part of the gas turbine is complex for higher cooling efficiency. Accordingly, if dust, etc. disturb the smooth flow of refrigerant or cooling holes are clogged with dust, etc., the cooling efficiency decreases and the gas turbine may be damaged. Therefore, the gas turbine requires highly purified refrigerant. Besides, refrigerant for cooling the high-temperature part of the gas turbine is required to be highly purified so that the refrigerant can flow smoothly through the complex cooling holes, its flow rate can be reduced as low as permissible, and the efficiency of the gas-turbine power-generating equipment can be increased.

For example, Japanese Unexamined Patent Application No. 54-82518 disclosed a configuration of air-cooled gas turbine wherein air discharged from a compressor is cooled by a heat exchanger, the pressure of the air is raised by



a booster compressor, and the air is fed to the high-temperature part of the gas turbine to cool the part and collected to a combustor.

Japanese Unexamined Patent Applications Nos. 2-264127, 2-267326, 7-189740, and 7-317562 disclosed technique for cooling the high-temperature part of the gas turbine.

In the case of the above air-cooled gas turbine, such problems are not addressed as the generation of mist due to the cooling of air by the heat exchanger, the damage of the booster compressor due to alien substances in cooling air, the decrease of the cooling efficiency and the damage to the turbine due to the clogging of cooling holes with alien substances in cooling air, and so on.

For example, if cooling air contains alien substances such as dust, the cooling holes, of which the configuration is complex for high cooling efficiency, may get clogged with such alien substances, reducing the flow rate of the refrigerant, and the gas turbine may be damaged.

The object of the present invention is to provide a gas turbine unit and a gas-turbine cooling method capable of feeding cooling air suitable for cooling the high-temperature part of the gas turbine.

Disclosure of the Invention

The gas turbine unit of the present invention comprises a compressor to compress and discharge gas, a combustor which the gas compressed by the compressor is fed to, and a turbine to be driven by the combustion gas of the combustor.

Further, primarily, its feature is that the gas turbine unit of the present invention has a turbine-cooling system to feed the gas from the compressor to the turbine. The turbine-cooling system comprises a heat exchanger to cool the gas compressed by the compressor and a means for separating liquid from the gas cooled by the heat exchanger.

The gas-turbine cooling method of the present invention for cooling a gas-turbine unit, which comprises a compressor to compress and discharge gas, a combustor which the gas compressed by the compressor is fed to, and a turbine to be driven by the combustion gas of the combustor, includes the process of feeding the gas from compressor to the turbine to cool it. The turbine-cooling process comprises the steps of cooling the gas compressed by the compressor and separating liquid from the cooled gas.

#### Brief Description of drawings

Fig. 1 is a system diagram of a cooling system of the high-temperature part of a gas turbine in accordance with the present invention.

Fig. 2 is a system diagram of a cooling system of the high-temperature part of a gas turbine in accordance with the present invention.

Fig. 3 is a system diagram of a cooling system of the high-temperature part of a gas turbine in accordance with the present invention.

Fig. 4 is a system diagram of a cooling system of the high-temperature part of a gas turbine in accordance with the present invention.

Fig. 5 is a system diagram of a cooling system of the high-temperature part of a gas turbine in accordance with the present invention.

Fig. 6 is a system diagram of a cooling system of the high-temperature part of a gas turbine in accordance with the present invention.

Best Mode for Carrying Out the Invention  
(First Embodiment)

With reference to Fig. 1, the first embodiment of the present invention will now be described in detail. Fig. 1 shows a cooling system of the high-temperature part of a gas turbine. The gas turbine unit of Fig. 1 comprises mainly a compressor 1 to compress and discharge gas, a combustor 2 which the gas compressed by the compressor 1 is fed to,

and a turbine 3 to be driven by the combustion gas of the combustor 2.

Arranged from upstream to downstream in the cooling system of this embodiment are a heat exchanger 4 for cooling the gas compressed by the compressor 1, a means for separating liquid from gas, a dust-collecting means for separating dust, etc. from gas, a booster compressor 7, and, again, a dust-collecting means for separating dust, etc. from gas.

Next, the cooling system of the high-temperature part of the gas turbine will be described concretely along the flow of cooling air.

The compressed air for cooling tapped from the compressor 1 through a branch line is fed to the heat exchanger 4. The compressed air fed to the heat exchanger 4 is cooled down to about 130°C. In this embodiment, the compressed air is indirectly cooled by a refrigerant. The cooled compressed air is fed from the heat exchanger 4 to a means for separating liquid from gas.

In this embodiment, a mist separator 5, which is a kind of gas-liquid separator, is adopted as the means for separating liquid from the gas fed from the heat exchanger 4. The mist separator 5 separates mist from the compressed air introduced in it. Namely, the mist due to the cooling of compressed air by the heat exchanger 4 is separated from

Thereafter, the compressed air is fed from the mist separator 5 to the dust-collecting means for separating dust, etc. from gas. In this embodiment, a cyclone 6 is adopted as the dust-collecting means for separating dust, etc. from gas. In the cyclone 6, alien substances such as dust contained in the cooled compressed air can be removed. By purifying the cooled compressed air in the cyclone 6, the booster compressor 7 disposed below the cyclone 6 can be prevented from being damaged by dust, etc. Besides, unlike

a filter with metal meshes, the cyclone 6, which is a centrifugal dust-collecting means, has hardly increasing pressure loss during its continuous operation and hence is capable of operating continuously over a long period of time. Namely, it is free from such clogging of meshes and increasing pressure loss as occur in a filter with meshes.

Namely, because the dust-collecting means for separating dust, etc. from gas is disposed below the heat exchanger 4 and the mist separator 5, dust, etc. in the air fed through the heat exchanger 4 and the mist separator 5 can be removed. In addition, because the dust-collecting means for separating dust, etc. from gas is disposed below the heat exchanger 4 and the mist separator 5 and above the booster compressor 7, dust, etc. in the air fed through the heat exchanger 4 and the mist separator 5 can be removed and hence the booster compressor 7 can be prevented from being damaged by dust, etc. On the other hand, by adopting a cyclone 6 as the dust-collecting means for separating dust, etc. from gas at this place, (i) the pressure loss hardly increases during the continuous operation, (ii) long-time continuous operation becomes possible, and (iii) such increase in pressure loss due to the clogging of meshes as occurs in a filter with meshes is rendered irrelevant.

Then, the compressed air is fed from the cyclone 6 to the booster compressor 7. The booster compressor 7 raises

the pressure of the compressed air to a desired level. At the time, the pressure is raised to about 50 kg/cm<sup>2</sup> optimal for cooling the turbine 3. In this way, the pressure of the compressed air can be raised by the booster compressor 7 to the level appropriate for cooling the turbine 3.

The booster compressor 7 is driven by the turbine shaft because cooling air always has to be fed to the turbine 3 while it is operating. However, the arrangement of equipment or limited available space may not allow such driving system to be adopted. In this case, the booster compressor 7 is driven by an electric motor. However, if the electric motor gets out of order, the supply of cooling air to the turbine 3 goes down. Therefore, it is desirable to provide the gas turbine unit with a protection device which stops the gas turbine immediately when the electric motor of the booster compressor 7 gets out of order. By providing the gas turbine unit with a protection device having a means for detecting the trouble of the electric motor and a means for stopping the gas turbine based on a signal from the trouble-detecting means, the gas turbine can be stopped to prevent it from being damaged in the event that cooling air is not sufficiently supplied to the high-temperature part of the gas turbine.

A dust-collecting means for separating dust, etc. from gas is disposed below the booster compressor 7. In this

embodiment, a filter 8 is adopted as the dust-collecting means. The compressed air for cooling is fed from the booster compressor 7 to the filter 8.

While the gas turbine is starting or stopping, the flow rate of the cooling air fed from the compressor 1 is low. Accordingly, the flow velocity at the inlet of the cyclone 6 is low, and hence the cyclone 6 may not be able to exert its dust-collecting capability well due to its working principle, purifying the cooling air insufficiently. On the other hand, the dust-collecting capability of the filter 8 which uses metal meshes or the like is not affected by the low flow velocity of the cooling air. Thus, when the flow velocity of the cooling air is low while the gas turbine is starting or stopping, the cooling air can be purified by the filter 8. Namely, by disposing, below the booster compressor 7, the filter 8 which is a means for separating dust, etc. from the cooling air by receiving the air with fiber or the like, the cooling air can be purified even while the gas turbine is starting or stopping and hence the flow velocity of the cooling air is low.

Besides, while the turbine 3 is operating at its rated speed, the pressure-raised compressed air (cooling air) is finally purified with excellent accuracy before the air is fed to the turbine 3. By purifying the air again, alien substances such as rust produced in the booster compressor



While the gas turbine is starting, stopping, or operating under a partial load, transient surges occur in the booster compressor 7. Before the turbine unit gets into such condition, the bypass valve 10 is opened to let part

On the other hand, while the gas turbine is starting, stopping, or operating under a partial load, the temperature of the combustion gas driving the turbine 3 is lower than that of the combustion gas during the operation at the rated speed. Therefore, the high-temperature part of the turbine 3 may be overcooled if all the cooling air is fed to the turbine 3. If the high-temperature part of the turbine 3 is cooled beyond the necessary degree, the temperature difference between the surfaces of the high-temperature part and the cooling holes may give rise to thermal stress, which may cause damage to the turbine 3. Therefore, excess cooling air is collected to the combustor 2 through the bypass line 11. Thus, excessive cooling air can be prevented from flowing into the turbine 3 because the bypass line 11 and the bypass valve 10 are provided. Namely, by controlling the bypass valve 10, the cooling air can be fed to the turbine 3 at an appropriate flow rate.

As described above, disposed in the bypass line 11 is the bypass valve 10 that is a flow-rate control valve to control the flow rate of the cooling air going around the turbine 3. By controlling the bypass valve 10, the necessary

Moreover, a more efficient cooling system for the high-temperature part of the turbine 3 can be constructed by monitoring metal temperatures of the high-temperature part of the turbine 3 or the temperature of the collected cooling air, and thereby determining whether the high-temperature part of the turbine 3 is properly cooled or not and controlling the bypass valve 10 accordingly. Namely, the cooling condition of the high-temperature part of the turbine 3 can be monitored by providing a means for detecting metal temperatures of the high-temperature part of the turbine 3 or the temperature of the collected cooling air. Besides, more appropriate cooling can be made and a more efficient cooling system for the high-temperature part of the turbine 3 can be constructed by providing a means for adjusting the bypass valve 10 based on metal temperatures of the high-temperature part of the turbine 3 or the temperature of the collected cooling air when the high-temperature part of the turbine 3 is not properly cooled.

It is preferable to close the bypass valve 10 completely from the point of view of the operating efficiency of the plant. However, the cooling condition of the high-temperature part of the turbine 3 may vary depending on weather conditions such as atmospheric temperature. Therefore, it is desirable to control the bypass valve 10 according to circumstances so as to optimize the cooling condition of the high-temperature part of the turbine 3.

Besides, in case of a gas turbine unit in which the cooling air after cooling the high-temperature part of the gas turbine is not collected into the combustor, but exhausted together with the combustion gas after driving the gas turbine, this cooling system can feed cooling air which flows smoothly through the high-temperature part of the gas turbine without causing the clogging of cooling holes with dust, etc. and thereby improves the reliability of the whole plant.

Further, in case of a closed-type cooling system, salient effect is achieved by purifying the cooling air.  
(Second Embodiment)

With reference to Fig. 2, the second embodiment of the present invention will now be described in detail. Fig. 2 shows a cooling system of the high-temperature part of a gas turbine.

Also provided in this embodiment is a flow control valve 13 which is a means for controlling the flow rate of refrigerant to the heat exchanger 4 in accordance with the temperature measured by the thermometer 12. With the flow control valve 13, the flow rate of refrigerant to the heat

exchanger 4 can be controlled in accordance with the temperature measured by the thermometer 12. This control of refrigerant enables the management and the control of the temperature of cooling air.

Moreover, provided in this embodiment is a differential pressure gauge 14 which is a means for measuring the difference between the pressures before and after the filter 8. The differential pressure gauge 14 enables to monitor the difference between the pressures before and after the filter 8 and the clogging of meshes of the filter 8. If the difference between the pressures before and after the filter 8 becomes large, the cooling air cannot be fed at a sufficient flow rate to the high-temperature part of the turbine 3. Therefore, it is desirable to provide the gas turbine unit with a protection device which stops the gas turbine immediately after such an event occurs.

Namely, damage to the gas turbine can be prevented by stopping the gas turbine on the basis of the measured value of the differential pressure gauge 14.

Also preferable for higher reliability is the configuration that at least two filters 8 are disposed in the cooling system in parallel and a selector valve 15 is disposed before and after each filter 8 so as to make switchover between the filters 8 and keep the difference

(Third Embodiment)

The gas turbine unit of Fig. 3 comprises mainly a compressor 1 to compress and discharge gas, a combustor 2 which the gas compressed by the compressor 1 is fed to, and a turbine 3 to be driven by the combustion gas of the combustor 2.

Particularly, in this embodiment, a plurality (at least two) of filters 16 is disposed in parallel below the mist separator 5 in the cooling system and a differential pressure gauge 14 is provided to measure the difference between the pressures before and after the filter 16 in service, as shown in Fig. 3. This configuration enables to

-18-

monitor the pressure loss of the filter 16 in service, make switchover among the filters 16, and change metal meshes of the filters 16 out of service.

Thus, continuous dust-collecting effect can be achieved, trouble due to the clogging of filter meshes can be prevented, the maintenance of filter meshes can be carried out easily, and an appropriate cooling system can be constructed.

Namely, the filters 16, as described in the present embodiments, can remove alien substances such as dust contained in the cooled compressed air. By purifying the cooled compressed air in the filters 16, the booster compressor 7 disposed downstream can be prevented from being damaged by such alien substances. Besides, the plurality of filters 16 is disposed in parallel, and the means for measuring the differential pressure of the filters 16 and the means for making switchover among the filters 16 are provided. Therefore, even if the filter 16 in service gets clogged with dust, etc. after a long service time, switchover among the filters 16 can be made and the pressure loss of the filter 16 in service can be prevented from increasing excessively.

Namely, because the dust-collecting means for separating dust, etc. from gas is disposed below the heat exchanger 4 and the mist separator 5, dust, etc. can be



(Fourth Embodiment)

The gas turbine unit of Fig. 4 comprises mainly a compressor 1 to compress and discharge gas, a combustor 2

which the gas compressed by the compressor 1 is fed to, and a turbine 3 to be driven by the combustion gas of the combustor 2.

Arranged from upstream to downstream in the cooling system of this embodiment are a heat exchanger 4 for cooling the gas compressed by the compressor 1, a means for separating liquid from gas and also separating dust, etc. from the same, a booster compressor 7, and a dust-collecting means for separating dust, etc. from gas.

In this embodiment, a gas-liquid-separating/dust-collecting device 18 is provided as the means for separating liquid and dust, etc. from gas. A filter 8 is disposed, below the booster compressor 7, as the dust-collecting means for separating dust, etc. from gas. The gas-liquid-separating/dust-collecting device 18 in the present embodiment serves as the means for separating liquid from gas (for example, a mist separator 5) of the first embodiment and, at the same time, as the dust-collecting means for separating dust, etc. from gas (for example, a cyclone 6) of the first embodiment. In addition to the double functionality, it contributes to the simplification of the gas turbine unit.

Moreover, the filter 8 may be omitted in this embodiment to simplify the unit because the filtering

(Fifth Embodiment)

The gas turbine unit of Figs. 5 and 6 comprises mainly a compressor 1 to compress and discharge gas, a combustor 2 which the gas compressed by the compressor 1 is fed to, and a turbine 3 to be driven by the combustion gas of the combustor 2.

In the example of Fig. 5, a gas-liquid-separating/dust-collecting device 18, which is a means for separating liquid and dust, etc. from gas, is disposed below the booster compressor 7.

Because the gas-liquid-separating/dust-collecting device 18 is disposed below the heat exchanger 4, the cyclone 6, and the booster compressor 7 and above the turbine 3, mist to be generated in the compressed air due to the cooling by

the heat exchanger 4 can be removed and erosion and dust-adhesion inside the cooling-air ducts of the high-temperature part of the turbine 3 can be prevented. In addition, by adopting the double-functional gas-liquid-separating/dust-collecting device 18, the gas turbine unit can be simplified.

Further, because the gas-liquid-separating/dust-collecting device 18 is disposed immediately before the turbine 3 in this embodiment, highly reliable and highly purified air can be fed to the turbine 3.

In the example of Fig. 6, a gas-liquid-separating/dust-collecting device 18, which is a means for separating liquid and dust, etc. from gas, is disposed between the cyclone 6 and the booster compressor 7.

Because the gas-liquid-separating/dust-collecting device 18 is disposed below the heat exchanger 4 and the cyclone 6 and above the booster compressor 7, mist to be generated in the compressed air due to the cooling by the heat exchanger 4 can be removed and erosion and dust-adhesion inside the booster compressor 7 and the cooling-air ducts of the high-temperature part of the turbine 3 can be prevented. In addition, by adopting the double-functional gas-liquid-separating/dust-collecting device 18, the gas turbine unit can be simplified.

### Industrial Applicability

According to the present invention, there is provided a gas turbine unit and a gas-turbine cooling method capable of feeding cooling air suitable for cooling the high-temperature part of the gas turbine.

**AMENDMENT UNDER ART. 34 PCT**

## Claims

1. (After Amendment) A gas turbine unit comprising a compressor to compress and discharge gas, a combustor which the gas compressed by the compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said compressor and a means for separating liquid from the gas cooled by the heat exchanger.

2. (Deleted)

3. A gas turbine unit comprising a compressor to compress and discharge gas, a combustor which the gas compressed by the compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said compressor, a liquid-separating means for separating liquid from the gas cooled by the heat exchanger, and



wherein said gas turbine unit has a turbine-cooling system to feed the gas from said first compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said first compressor, a liquid-separating means for separating liquid from the gas cooled by the heat exchanger, a dust-collecting means for separating dust, etc. from the gas having passed through the liquid-separating means, and a second compressor to raise the pressure of the gas having passed through the dust-collecting means to a desired level.



10. A gas turbine unit comprising a first compressor to compress and discharge gas, a combustor which the gas compressed by the first compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said first compressor to the turbine to cool the turbine and to feed the gas from the turbine to the combustor, said turbine-cooling system comprising an indirect cooling heat exchanger to cool the gas compressed by said first compressor, a mist separator for separating liquid from the gas cooled by the heat exchanger, a cyclone for separating dust, etc. from the gas having passed through the mist separator, a second compressor to raise the pressure of the gas having passed through the cyclone to a desired level and a filter for separating dust, etc. from the gas whose pressure has been raised by the second compressor.

11. (Deleted)

12. (Deleted)

13. (After Amendment) A gas turbine unit as claimed in any one of claims 5 through 7, wherein a means to measure the temperature of the gas cooled by the heat exchanger is provided.

14. (After Amendment) A gas turbine unit as claimed in any one of claims 5 through 7, wherein a means to measure the temperature of the gas cooled by said heat exchanger and a means for controlling the supply of refrigerant to said heat exchanger in accordance with the temperature measured are provided.

15. A gas turbine unit comprising a first compressor to compress and discharge gas, a combustor which the gas compressed by the first compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said first compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said first compressor, a means to measure the temperature of the gas cooled by the heat exchanger, a means for controlling the supply of refrigerant to said heat exchanger in accordance with the temperature measured, a liquid-separating means for separating liquid from the gas cooled by the heat exchanger, a first dust-collecting means for separating dust, etc. from the gas having passed through the liquid-separating means, a second compressor to raise the pressure of the gas having passed through the dust-collecting means to a desired level, and a second dust-collecting means for separating dust, etc. from the gas whose pressure has been raised by the second compressor, said second dust-collecting means being at least two filters disposed in parallel in the cooling system of the turbine.

16. A gas turbine unit comprising a first compressor to compress and discharge gas, a combustor which the gas compressed by the first compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said first compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said first compressor, a dust-collecting means for separating dust, etc. from the gas cooled by the heat exchanger, and a second compressor to raise the pressure of the gas having passed through the dust-collecting means to a desired level, said dust-collecting means being at least two filters disposed in parallel in the cooling system of the turbine.

17. A gas turbine unit comprising a first compressor to compress and discharge gas, a combustor which the gas compressed by the first compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said first compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said first compressor, a dust-collecting means for separating dust, etc. from the gas cooled by the heat exchanger, and a second compressor to raise the pressure of the gas having passed through the dust-collecting means to a desired level, said dust-collecting means being at least two filters disposed in parallel in the cooling system of the turbine, a pressure detector being provided to detect the difference between the pressures before and after the filter, and passage opening-and-closing means being disposed above and below the cooling system of the filter to each

control the flow of the air into the filter.

18. A gas turbine unit comprising a first compressor to compress and discharge gas, a combustor which the gas compressed by the first compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said first compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said first compressor, a liquid-separating means for separating liquid from the gas cooled by the heat exchanger, a first dust-collecting means for separating dust, etc. from the gas having passed through the liquid-separating means, a second compressor to raise the pressure of the gas having passed through the first dust-collecting means to a desired level, and a second dust-collecting means for separating dust, etc. from the gas whose pressure has been raised by the second compressor, said first dust-collecting means being at least two filters disposed in parallel in the cooling system of the turbine.

19. A gas turbine unit comprising a compressor to compress and discharge gas, a combustor which the gas compressed by the compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said compressor to the turbine, said

wherein said gas turbine unit has a turbine-cooling system to feed the gas from said first compressor to the turbine, said turbine-cooling system comprising a heat exchanger to cool the gas compressed by said first compressor, a dust-collecting means for

wherein said cooling method includes a process to cool the turbine by feeding the gas from said compressor to the turbine, said

cooling process comprising a step to cool the gas compressed by said compressor, and a step to separate liquid from the cooled gas.

24. (Deleted)

25. A gas-turbine cooling method for a gas turbine unit comprising a compressor to compress and discharge gas, a combustor which the gas compressed by the first compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein the gas compressed by said compressor is cooled, the pressure of the gas cooled is raised to a desired level, and after dust, etc. are separated from the gas whose pressure has been raised, the gas is fed to the turbine so that the turbine may be cooled.

26. A gas-turbine cooling method for a gas turbine unit comprising a compressor to compress and discharge gas, a combustor which the gas compressed by the compressor is fed to, and a turbine to be driven by the combustion gas of the combustor;

wherein the gas compressed by said compressor is cooled, liquid is separated from the gas cooled, dust, etc. are separated from the separated gas, the pressure of the separated gas is raised to a desired level, and after dust, etc. are separated from the gas whose pressure has been raised, the gas is fed to the turbine so that the turbine may be cooled.

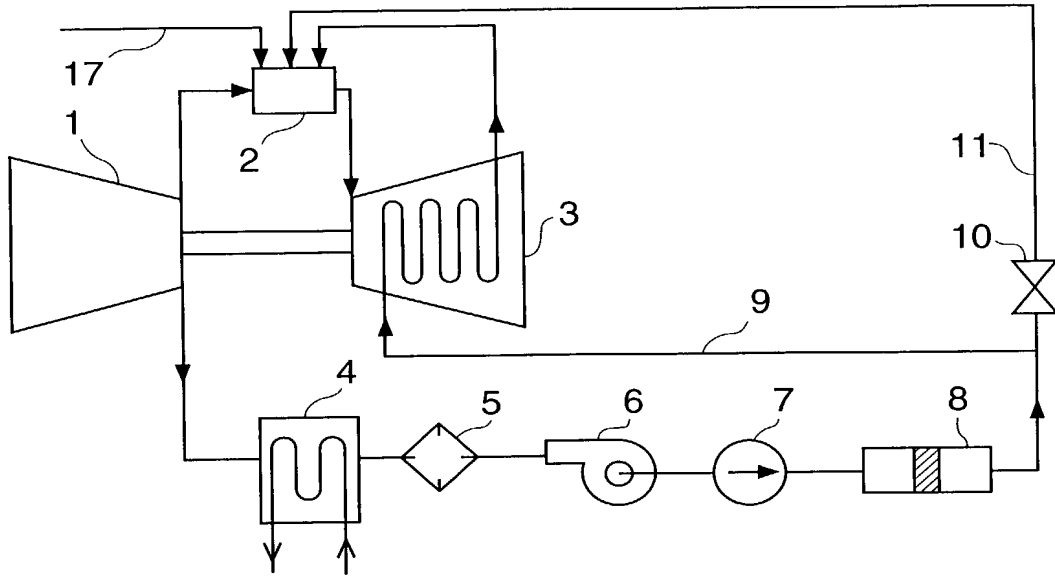


said cooling method includes a first step to cool the gas compressed by said compressor, a second step to separate dust, etc. from the gas cooled, a third step to raise the pressure of the separated gas to a desired level, a fourth step to cool the turbine by feeding the gas whose pressure has been raised to the turbine, and a step, either between said second and third steps or between third and fourth steps, to separate liquid and dust, etc. from the gas.

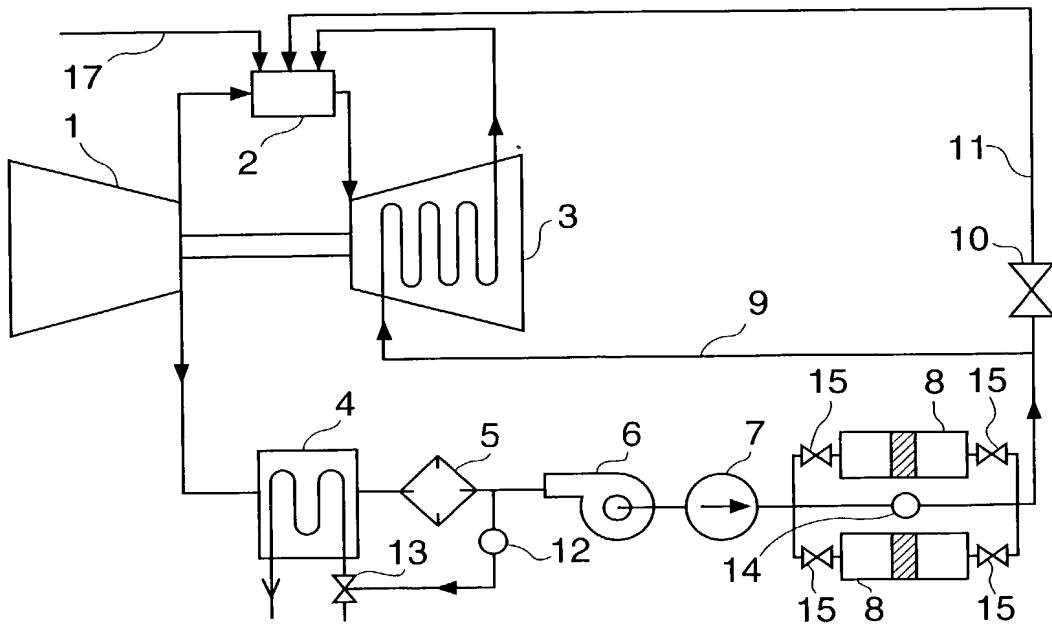
It is the object of the present invention to feed cooling air suitable for cooling the high-temperature part of the gas turbine.

Thus, according to the present invention, it becomes possible to feed cooling air suitable for cooling the high-temperature part of the gas turbine and to achieve higher reliability of the gas turbine unit.

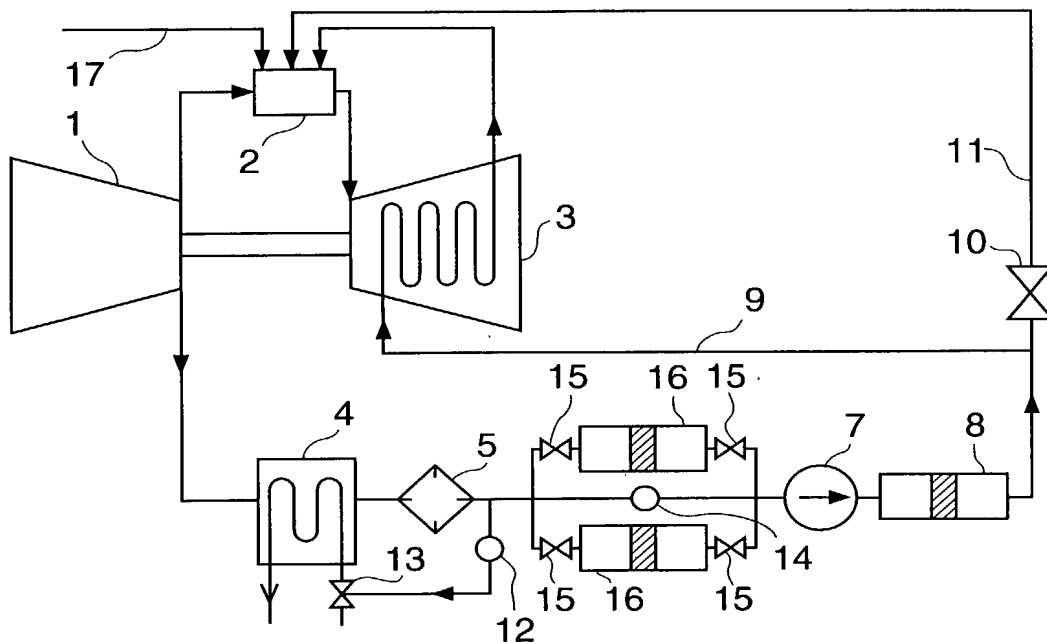
**FIG.1**



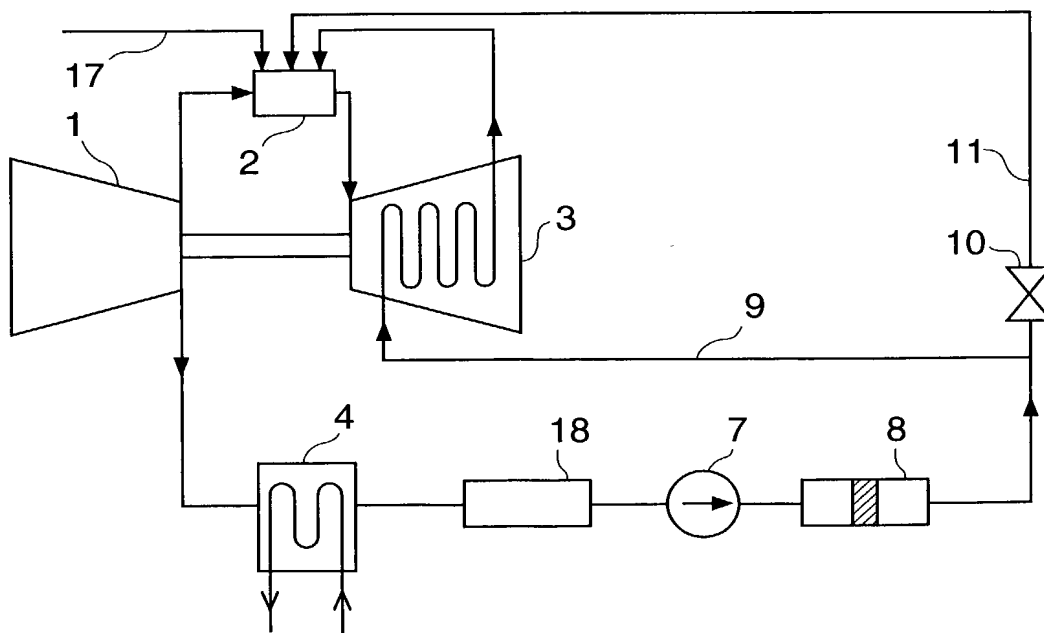
**FIG.2**



**FIG.3**

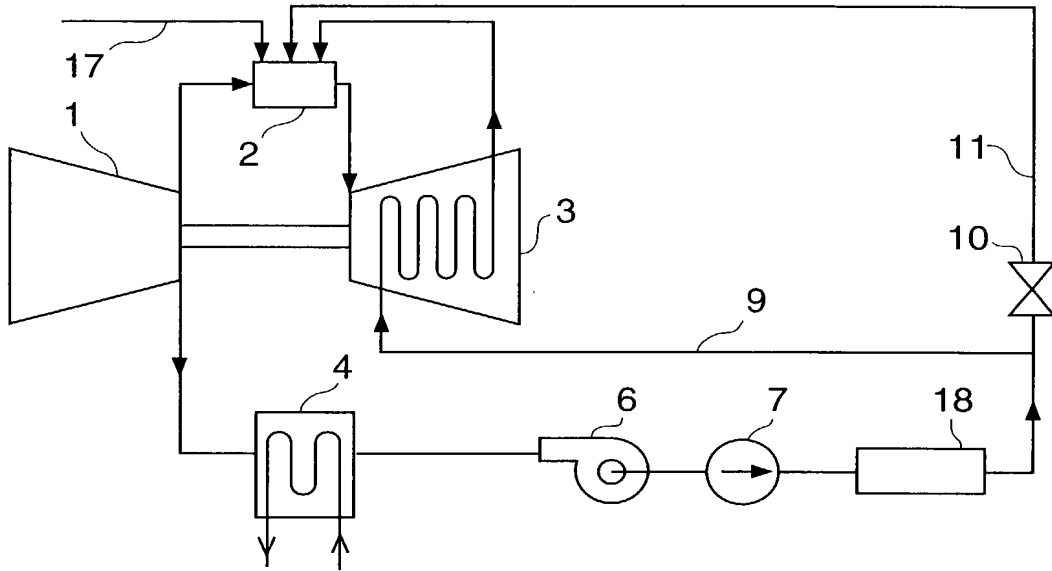


**FIG.4**

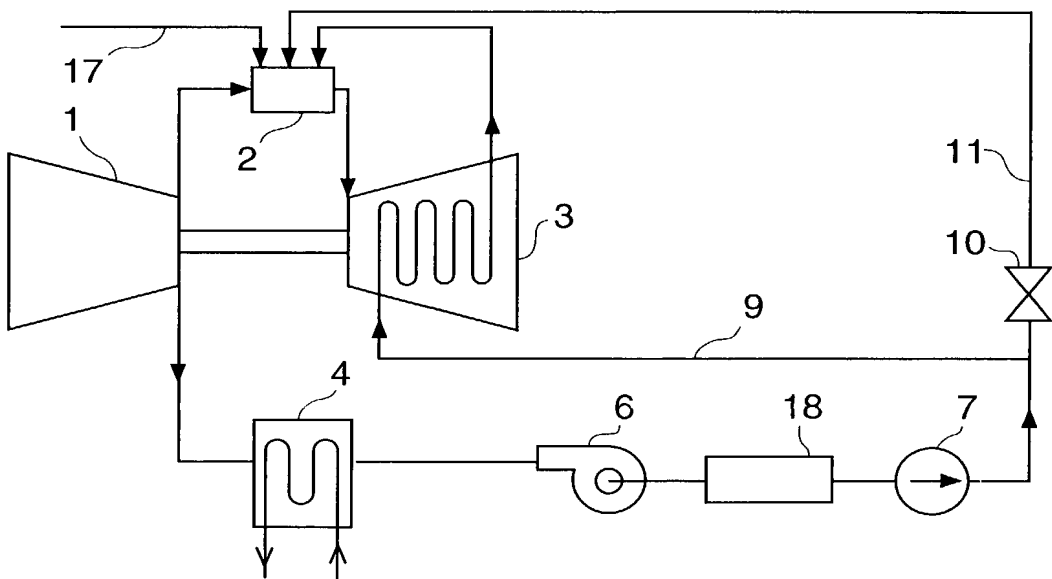


3/3

**FIG.5**



**FIG.6**





**Japanese Language Declaration**  
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### Prior Foreign Application(s)

## 外国での先行出願

Priority Not Claimed

優先権主張なし

(Number)  
(番号)

(Country)  
(国名)

(Day/Month/Year Filed)  
(出願年月日)

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(Number)  
(番号)

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(国名)

(Day/Month/Year Filed)  
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(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

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(出願番号)

(Filing Date)  
(出願日)

(Status: Patented, Pending, Abandoned)  
(現況: 特許許可済、係属中、放棄済)

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**POWER OF ATTORNEY:** As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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